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The Splashing of Rain

By LIEUT.-COL. E. GOLD, D.S.O., F.R.S.

The funnel of a rain-gauge is so constructed that any splashing of raindrops falling into the gauge is not likely to result in the splashed drops leaving the gauge. They will generally be caught by the vertical sides of the funnel. If therefore the gauge is to record the correct amount of rainfall it must be set at such a height that the drops of rain falling outside the gauge will not splash as high as the gauge. If they do, then, in addition to the rain which falls from above, entering the gauge, there will be splashed rain going into it.

Gauges in England are set at a height of 1 foot above the ground, and it has been generally assumed that this height is great enough to prevent any appreciable amount of splashed water entering the gauge. The height has been accepted mainly because it seemed reasonable; but I know of no experimental evidence for the selection of a height of 1 foot as being sufficient to ensure freedom from errors due to splashing; evidence might be obtained by letting artificial rain fall around a rain-gauge above which was placed a concentric cylinder of larger diameter. to prevent any rain falling directly into the rain-gauge. The base of the cylinder must not be at a greater height above the top of the funnel of the rain-gauge than $(R-r)\frac{v}{V}$ where R and r are the radii of the cylinder and the gauge and v and V are

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the vertical velocity of the raindrops and the horizontal velocity of the wind. If this condition were satisfied any drops carried by the wind which missed the bottom of the cylinder would be below the top of the funnel when they reached it, and would not therefore enter the gauge. Any water which was caught by the gauge would be due to the splashing of the drops.

In natural rain the drops are usually of different sizes, and it would not be practicable to disentangle the effect of the smaller drops which were carried into the gauge by the wind from the drops carried in by splashing. It would be necessary to make an artificial rain with drops approximately all of one size.

Another way of approaching the problem is to utilise the known facts that raindrops do not in practice exceed a limiting diameter of about 7mm., and that the greatest velocity of raindrops is about 25 feet per second; this occurs with drops of about 5mm. diameter; the larger drops take a form in which the increased resistance of the air more than balances the increased weight of the drop. When a raindrop strikes the ground it cannot rebound with a greater vertical velocity than that which it has before impact. Consequently a raindrop cannot start splashing upwards with a greater vertical velocity than 25 f./s. If there were no air resistance the greatest height to which such a drop could reach would be $\frac{25 \times 25}{64}$ *i.e.*, about 10 feet. Actually there would be appreciable air resistance. In fact at the commencement the air resistance would be equal to the weight of the drop so that initially the retardation in the ascending motion of the drop would be twice the value of gravity. At the end of the motion there would be no air resistance, because the drop would have no vertical velocity. Thus the retardation being initially equal to 2 g and finally equal to g, would be on the average about $1\frac{1}{2}$ g. The effect of this would be to reduce the maximum height to $\frac{25 \times 25}{96}$ or about 7 feet. More exact calculation gives a value of $\frac{25 \times 25}{64} \log_e 2 = \frac{25 \times 25}{92}$

In practice drops of 5mm. diameter would not rebound with the velocity with which they struck the ground. They would normally break up into smaller drops, and the height to which these smaller drops would ascend would be very much less than 7 feet. Drops of 5mm. diameter would only be met with in thunderstorm rain. In ordinary rain the drops would be of much smaller diameter. In moderate rain they appear to vary from about 0·5mm. to 2 or 3mm. If we consider a drop of 2mm. diameter this would have a limiting velocity of about 20 feet per second. If such a drop rebounded with the velocity with which it struck the ground it would not ascend to a height greater than 4 feet.

The assumption that the drops rebound with a velocity equal to that with which they strike the ground is equivalent to taking the drops as solid bodies of perfect elasticity and the calculation of heights depends upon the assumption that there is no wind and no carrying up of the splashed drops by turbulence in the air. It may be noted that if a comparatively large drop of 2mm. in diameter breaks up into eight small drops, each of 1mm. in diameter, these small drops could not rise to a greater height than about 2 feet or half the maximum height to which the 2mm. drop could rise, if it rebounded as a single drop.

In anticipation of more precise experiments on the splashing of falling drops, I thought it would be of interest to make one or two observations on isolated drops falling on a glass plate. I let the drops fall from the end of a camel-hair brush; actually I took on each occasion the last drop which fell; it appeared to be about 4mm. in diameter. The diameter of the drop can be obtained by weighing the drop. I have since weighed drops from the brush I used; they weighed approximately 65mgm. corresponding with a diameter of approximately 5·0mm. The drops fell from two heights, one about 40cm. (16 inches) and the other about 140cm. ($4\frac{1}{2}$ feet). The velocity with which the drop struck the plate, assuming a limiting velocity of 20 f./s., would be about 9 f./s. and 14 f./s. respectively. When the drop struck the plate it neither rebounded nor broke up; it just spread out in a circular patch, practically a perfect circle. This surprised me; I thought at first that it was due to the small height from which the drop fell, viz., 40cm. But when I tried the larger height, the result was the same, only the circle was larger. The edge of the circle was nearly a continuous line, but in some cases it was broken by one or two minute spurts from the main mass of liquid. When the drop fell from a height of 40cm. the radius of the circle on the plate was approximately 1·3cm.; when it fell from a height of 140cm. the radius was approximately 1·8cm. In rain in thunderstorms drops form circles on a glass plate: the largest I caught made a circle of about 4cm. diameter (2cm. radius), there were many of about $1\frac{1}{4}$ to $1\frac{1}{2}$cm. radius. Ordinary rain after the storm made patches of diameter from 1mm. to 6mm. mainly.

The explanation of the spreading out of the drops is briefly this—when the drop strikes the plate the kinetic energy of the falling drop is converted into potential energy of surface tension. This latter is proportional to the area of the surface of the water in contact with the air (assuming that the drop wets the plate. If we assume that the drop is spherical (actual drops are not truly spherical), of radius r, then the potential energy of the surface tension of the falling drop $=4\pi r^2T$ (the value of T in C.G.S. units is approximately 76). If the radius of the circle into which the drop spreads out is R then the potential

energy of the surface tension of the circular patch is πR^2T or $\pi R^2(T+T^1)$ if there is a surface tension T^1 on the water in contact with the glass. The difference between these two, viz., $\pi T(R^2-4r^2) + \pi R^2T^1$ ought to be approximately equal to the kinetic energy of the falling drop.

If L is the limiting velocity of the falling drop, *i.e.*, the velocity which it would attain after falling a very long distance through the air, it is possible to compute the kinetic energy which the drop will have after falling a distance h. The actual formula is $\frac{1}{2}mL^2(1-e^{-2gh/L^2})$ where m is the mass of the drop and g is the acceleration of gravity. The limiting velocity L does not vary much with the size of the drops after they have reached a diameter of about 2mm. We may therefore assume approximately for the drops with which I made experiments a value of L of about 20 f./s. (=600cm./sec.).

With this limiting velocity the formula gives as the kinetic energy of a drop which has fallen a distance of 40cm. a value of 35400 × m, m being the mass of the drop. (If there were no air resistance the corresponding value would be 39200 × m—not very different, as one would anticipate because the air resistance cannot produce much effect in a small fall like 40cm.). The actual velocity of the drop after falling 40cm. would therefore be 266cm./sec. allowing for the air resistance, or 280cm./sec. allowing for no air resistance. The corresponding values of kinetic energy for a fall from a height of 140cm. are 83400 × m allowing for air resistance and 137500 × m allowing for no air resistance. The difference in this case is very considerable; the air resistance reduces the terminal velocity from 525cm./sec. to 410cm./sec. For spherical drops of water the value of m is $\frac{4}{3}\pi r^3$. If these values for the kinetic energy and the measured values of the diameters of the circular patches are used to calculate the diameter of the drops on the assumption that T^1 is negligible, they come out as 2·8mm. and 2·6mm. for the 40cm. and for the 140cm. fall respectively. These are smaller than the true diameter found by weighing, viz., 5·0mm., the explanation probably is that T^1 is of appreciable size and that part of the kinetic energy is used in overcoming the skin friction between the glass and the water as the latter spreads out.

The fact that when the drops strike a hard surface like a sheet of glass they spread out was new to me. I had often observed, as other people have done, that the first drops of rain falling on a hard pavement spread out into circles, but I had, rather casually, assumed that this was due to the warmth and dryness of the pavement, and had not realised that it was due to the surface tension of the drop acting in the manner I have mentioned.

When a drop falls on a water surface the effect is quite

different. It cannot dispose of its kinetic energy by spreading out and increasing the potential energy of the surface tension; if it spreads on a water surface it merely replaces the potential energy of the water over which it spreads by a new surface of equal potential energy: there is no increase in area of the film. Since this avenue of disposing of the kinetic energy is closed, the drop splashes and the kinetic energy of the drop falling on water is transformed partly into waves on the water surface and partly into kinetic energy of the splash; even for a drop falling quite a short distance there is a definite splash when it falls on a water surface.

I do not know of any experimental or theoretical evidence as to the partition of energy between the wave and the splash; but if we assume that the energy is equally divided between the wave and the splash then the heights to which different drops will splash when they fall upon a water surface is shown in the following table. The heights are given on the assumptions—

(*a*) that the drop is equal in size to the falling drop;

(*b*) that there are two splashing drops each half the size of the falling drop;

(*c*) that there are eight small drops each one-eighth the size, *i.e.*, half the diameter of the falling drop.

(*d*) that there are 64 small drops each one-quarter the diameter of the falling drop.

Diameter of drop. mm.		Heights of splash. (*a*)	(*b*)	(*c*)	(*d*)
				feet.	
1	...	1·3	1·2	1·1	0·5
2	...	2·4	2·1	2·0	1·4
3	...	3·3	3·0	2·9	1·9
4	...	4·2	3·8	3·8	2·2
5	...	4·2	4·2	4·2	2·7

These are maximum values: when the drop breaks up the smaller drops do not start vertically but fly out at a comparatively small angle with the horizontal—30° or less. These values suggest that a height of 1 foot is not sufficient to avoid with certainty the effect of splashing, and that from this aspect a height of 3 or 4 feet is necessary.

After I had made the observations mentioned here, I had an opportunity of watching the splashing of raindrops falling with thunderstorm intensity practically in a calm. Individual drops of appreciable size appeared to rise to a height of about 6in. Smaller drops I could not see individually, but I was able to estimate roughly the height to which these drops of smaller size rose by observing the mist which they produced. The upper limit of this mist when viewed at a distance of about 100 yards is fairly definite. On the occasion in question it was well above

the level of the hubs of motor cars, and nearly as high as the tops of the wheels, *i.e.*, the mist rose to a height of about two feet. This value may be compared with the values in column (*d*) of the table above which corresponds with a large number of small splashed drops. (These observations were made from the door of Adastral House facing Aldwych about 6 p.m. on August 5th, 1931.)

It is clear to me now that the ordinary splashing of rain is due to the rain falling on a wet surface, and is not due to its falling on a hard surface. In fact, the best way to avoid any splashing of rain would be to keep the surface, on which it falls, dry.

Thunderstorms, August 3rd to 5th

A spell of thundery weather was experienced early in August, and commenced in a most abnormal manner. On August 3rd there was a large and recently formed anticyclone extending from the Atlantic across Scotland to Norway, with a pressure of about 1030mb. along the axis. There was a steep gradient for NE. winds over most of England and Wales, and many places on the coast had strong winds all day. Pressure over France was still relatively low, but had risen about 10mb. in the preceding 24 hours, and was still rising. NE. to E. winds extended up to high levels. Rain and local thunder occurred during the early hours of the 3rd in a belt from Yorkshire to the west Midlands, and broke out after dusk over south-east England, soaking many of the Bank Holiday crowd. The storms moved westward as far as Pembroke during the latter part of the night. Taking into account the strength and depth of the NE. wind, it would be difficult, if not impossible, to find any close precedent to these storms. The general warmth over land areas, and also the upper air temperature at Duxford on the morning of the 4th, showed that the surface air had been cooled over the North Sea. There was a wind discontinuity over northern France, apparently a cold front with the cooler air on the south side. The evening storms might possibly be regarded as a case of pre-cold-frontal rain, an unusual variety of a common, but unexplained phenomenon.

The NE. winds began to decrease immediately after the storm and became light within 36 hours. On August 5th the northern anticyclone collapsed and a complex shallow depression moved northward from France to the North Sea and deepened. Thunderstorms occurred at many places in the south on the 4th. over most of England on the 5th, and near the south-east coast on the morning of the 6th, and were severe locally. On the 4th 4.44in. of rain fell at Langford, Salisbury, between 6.5 and 7.35 p.m. (*The Times*, August 7th. The time is probably

summer time.) Between 10.40 and 10.50 p.m. G.M.T, fully half an inch fell at Ross-on-Wye. During the afternoon of the 5th 2·90in. of rain were recorded at Petersfield in about an hour, and 2·15in. in 55 minutes at Stoner Hill, a few miles off. On the same evening 2·22in. fell at Greenwich after 6 p.m. G.M.T., and about an inch at Kingsway between 4.55 and 5.25 G.M.T. At Kensington there was none at that time, and only 0·08in. altogether, while Westminster had only 0·04in. Flooding ooccurred at King's Cross, with derangement of traffic, and also in some other parts of London, though the heavy rain was patchy. Heavy hail fell at Biggin Hill and in the Caterham Valley. The thunder and lightning were not frequent during the heavy rain in central London, but subsequently were fairly frequent and severe, especially over some of the south-west and west suburbs about 7 p.m. G.M.T. A number of houses were struck in various parts of the town. The storm lasted for three hours in the London area, and its movement was extremely slow and somewhat irregular. The average drift of the main thunder-clouds was from about south-east, but was rather variable, and as the result of complex movements and developments, the centre, north and east of London had the storm about two hours earlier than the south-west. The first storm broke directly over central London and moved very slowly towards north-north-east, joining on to others forming in the east and south-east.

Humidity was high throughout the period, the dew point being up to 67°F. locally on the 4th, though this must have been partly due to the previous night's rain. The air at 2,000 feet can be traced back from south England to south Russia, using gradient winds, and it is difficult to see why it was so damp. Possibly a depression over south Russia on July 31st was connected with it. The dampness was undoubtedly the main factor in producing the storms. An upper air observation at Duxford at 6.15 a.m. on the 4th showed that the upper air temperature was above the August normal, but that the lapse rate above 3,000 feet was slightly above the saturated adiabatic, with a very high humidity. Observations at four German stations on the 3rd showed similar features as regards temperature, but somewhat lower humidities, though the total water content was considerable. Thunderstorms occurred on that day in south Germany, but were not reported from north Germany or Holland. In parts of France there were storms from the 1st till the 6th, and they were especially severe over northern France late on the 4th, when there were at least 12 deaths from lightning and great material damage. It is quite common to have an adequate moisture supply for thunderstorms and heavy rainfall in air which has been over land for a considerable period.*

C. K. M. DOUGLAS.

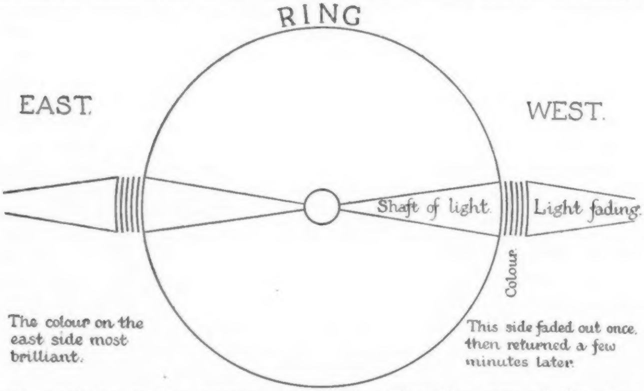
* See *Meteorological Magazine* 65 (1930) p. 130, also 61 (1926) p. 156.

Correspondence

To the Editor, *The Meteorological Magazine.*

Mock Moons

Mr. Hobday of 29, Cecil Street, Stockton-on-Tees, writes, that "At Thornaby-on-Tees, Saturday, March 7th, 1931, at 3.30 a.m., we witnessed a sight which must be of a rare occurrence. At the time stated the moon was very bright and surrounded by a large narrow ring. From the moon two shafts of light extended, one east, one west. When these shafts of light reached the ring the colours of the rainbow appeared, then the shafts of light gradually tapered away. The remarkable thing about it all was the distinctness of the rainbow colours, which were as clear as such seen during summer showers. The shafts of light were exactly similar to the beam from a searchlight. We first noticed it as stated at 3.30, and it lasted until 3.50 a.m. The sketch gives an idea of the shape

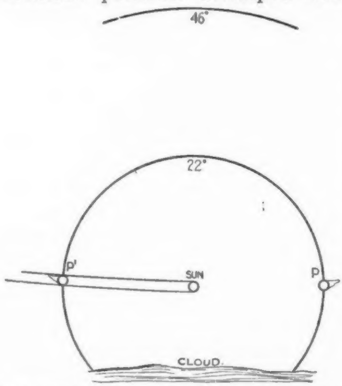


and position of the parts mentioned. The diameter of the ring was about thirty times the diameter of the moon. A seafaring man who also saw it says that he has seen the same before, but always in the tropics. The sailors called it 'The Wind Dogs,' and it was a sign of very bad weather." Mr. Sargent of the Observatory, Durham, who sent Mr. Hobday's observation, writes that "Weather conditions here leave it quite possible from that point of view, as clouding was very partial, and snow storms brief with fair intervals. Thornaby, from whence the appearance was seen, lies (practically) between Stockton-on-Tees and Middlesbrough, really an 'across river' part of Stockton itself." In commenting on the above observation, Dr. Whipple says that "I feel sure that Mr. Hobday saw the 22° halo, the mock-moon ring and mock moons. The mock-

moon ring is attributed to the reflection of light from ice crystals with vertical axes. It is possible that the diffraction by such crystals also plays a part in the phenomena. The mock-moons are due to refraction by crystals of the same class. The brilliance of the colours implies that the crystals were exceptionally numerous. As to the size of the halo it may be surmised that the circle was not complete or, more probably, that there is a mistake about the time. The fact that the mock-moons were on the outside of the halo implies that the moon must have been a considerable height above the horizon and therefore favours the hypothesis that the time is at fault. The mock-sun ring is not often seen in this country. I do not remember any instance of the mock-moon ring."

Halo Phenomena

Throughout to-day there was a halo of 22°. About 16h. two brilliant parhelia developed with white tails about ½° long. On examination in the black mirror the parhelic circle could be traced from the sun to the left parhelion, which was especially bright, and about 4° or so beyond it. The right parhelion also had a tail but cloud prevented exact observation. The halo itself, which was faint, appeared in cirro-nebula, the sky being only slightly milky. About 17h. the upper part of the halo of 46° was observed, faintly, but distinctly enough for the greater purity of the colours as compared with the 22° halo to be noted.



CICELY M. BOTLEY.

Guildables, 17 Holmesdale Gardens, Hastings. May 1st, 1931.

Sun Pillar, May 18th, 1931

A sun pillar was observed at Holyhead on May 18th, at 20h. G.M.T., as a well-defined column of light, pale orange in colour with a " background " of fine cirrus cloud of a darker reddish tint.

The base of the pillar, about ½° in width was some 5° above the horizon due to mist out at sea. The column rose to an

altitude of from 10° to 15°. The sky was 2/10ths clouded with cirrus cloud in the west and alto-cumulus cloud in the east. The phenomemon lasted until 20h. 20m. G.M.T. Unfortunately no observations were made when the sun was visible.

H. L. PACE.

Salt Island, Holyhead. May 20th, 1931.

Limits of Visibility

Mr. J. C. Ridgway inquires in the July number of the Magazine whether Hindhead is often visible from the Terrace at Richmond. Though not a resident in Richmond, I often walk along the Terrace either in the morning or evening, and Hindhead is frequently visible in summer. Visibilities of over 30 miles are fairly common in the south-east in summer, but the extreme limit is difficult to determine owing to absence of suitable objects. From the air I have seen the coast line up to 100 miles' distance. Clouds or mountains are sometimes visible much further. There is no reason to doubt Major Goldie's conclusion that he saw clouds 200 miles off over Norway.

C. K. M. DOUGLAS.

In connexion with the note on the above subject by A. H. R. Goldie in the May number of the magazine, it may be of interest to note the great distances at which mountain peaks and ranges are frequently visible in north-west India. To the north-west of Peshawar, which is 1,500 feet above sea-level, the Hindu Kush mountains, a large branch of the western Himalayas in Afghanistan, can quite often be seen—especially in the winter months. The range has a general height of 12/13,000 feet—with peaks extending up to 18,000 feet—the nearest point being 175 miles away from Peshawar. After the passage of a western disturbance, the peaks are generally remarkably clear and seem to be much nearer than they really are. Occasionally in the cold weather, the high peaks over 200 miles away to the north of Peshawar (where the Hindu Kush joins the Pamirs) can also be seen from the air at a height of 5,000 feet. These peaks are all over 20,000 feet high—Terichmir, for example, is 25,000 feet above sea-level—but they cannot be seen from the ground owing to the intervening hills. Another famous mountain which can sometimes be seen from certain points in the Peshawar district is Nanga Parbat. This mountain is in the Gilgit Agency of Kashmir and extends to a height of 26,620 feet—towering many thousand feet above the adjacent hills. It is situated north-east of Peshawar and is approximately 200 miles away.

R. G. VERYARD.

No. 1 *(Indian) Group Headquarters, R.A.F., Peshawar. June 24th*, 1931.

Cloudless Days

The sky was almost cloudless yesterday—but not quite. During the last fifteen years there have been only twenty-three entirely cloudless days in this district (the period April to December, 1919, is not covered by my record). I have no record of a cloudless day in 1919, 1920, 1923 and the present year so far. Days which were quite free from cloud, since March, 1916, are as follow :—

2nd April, 1916			12th Mar., 1924	
6th Feby., 1917			10th June, 1925	
31st Jany., 1918	2		13th April, 1926	
9th April, 1918			10th Feby., 1927	
8th April, 1921	6		15th July, 1928	
22nd May, 1921			8th Mar., 1929	5
9th July, 1921			28th Mar., 1929	
10th July, 1921			6th April, 1929	
8th Sept., 1921			24th May, 1929	
18th Oct., 1921			7th Sept., 1929	
27th May, 1922	2		4th Nov., 1930	
7th June, 1922				

MILES W. BINNS.

47, *Leicester Road, Lutterworth, Rugby.* *June 27th*, 1931.

Week-end Weather in 1931

The wet weather that has prevailed during several recent week-ends has been the subject of much newspaper press comment. On Monday last in particular such striking headlines as " Dreary Week-End ! " " Why are Week-Ends Always Wet ? " appeared in many leading dailies. The emphatic statement that 25 out of the 30 week-ends in 1931 have been wet in south-east England has led me to examine the records of Lympne to see how far such a statement can be substantiated. Lympne is no great distance from any of the numerous popular holiday resorts of Kent, so that it seems fair to use its records for the present investigation. For this analysis a week-end has been taken as comprising the two days Saturday and Sunday.

Of the 30 week-ends in the first seven months of 1931, eight had no measurable rain, eleven had rain on either Saturday or Sunday, and eleven had rain on both Saturday and Sunday; five week-ends had more than 10mm. (·40in.), the wettest being April 18-19th, with 21·3mm. and July 25th-26th with 14·5mm.

Sunshine is such an important element in any consideration of week-end weather that it is worth while noting that in the period under review no week-end was absolutely sunless. There were, however, eight week-ends when either Saturday or Sunday had no sunshine, and a further thirteen when the duration for the two days was less than 50 per cent. of the possible amount.

Of the nine week-ends remaining, which with more than 50 per cent. of the possible duration might perhaps be described as "sunny," six were also rainless, so that conditions have not been so dismal as the newspaper press would have us believe. The highest sunshine values, 28·8 hours, occurred in the brilliant week-end of June 27th-28th.

Nevertheless it is a fact that conditions on Saturdays and Sundays have generally been markedly inferior to those prevailing from Monday to Friday, as may be gathered from the following data :—

January—July 1931	Rainfall		Sunshine	
	Total	Average per day	Total	Average per day
	mm.	mm.	hrs.	hrs.
Mondays—Fridays, 152 days	213.1	1.4	792.6	5.2
Saturdays and Sundays, 60 days	128.1	2.1	282.0	4.7

The striking facts emerge that the mean daily rainfall on Saturdays and Sundays in 1931 has been 50 per cent. greater, and the duration of sunshine 10 per cent. less than on other days of the week.

The normal rainfall at Lympne for the first seven months of the year is 340mm., giving a daily rate of fall of 1·6mm. The total fall for the first seven months of 1931 had been 341mm., so that the year so far has been remarkable in that, while the total precipitation is almost exactly normal, Mondays to Fridays have had appreciably less than their normal rainfall, while Saturdays and Sundays have had considerably more than the normal.

H. E. CARTER.

Lympne Air Port, Hythe, Kent. August 1st, 1931.

Rainstorms of July 5th and 6th, 1931

Dr. G. F. Barbour, of Fincastle, Pitlochry, writes that the rainfall for the 24 hours from 9h. on the 5th to 9h. on the 6th during which the thunderstorm took place was 1·50in.—0·52in. less than the very exceptional rainfall on June 14th, but it was more concentrated, as a large portion fell between 6 and 8 p.m. (summer time). At Fincastle Ho. the storm began within a few minutes of 6 p.m. with a hailshower of exceptional severity lasting about 8 minutes, the largest hailstones being approximately ½in. in diameter. No hail was observed at neighbouring stations.

Mr. J. Gibson, of Waringstown, near Lurgan, Co. Down,

writes that thunderstorms were experienced to the south, north-east and north-west of the station, most of the afternoon of the 6th. In the evening another thundersorm occurred at Annaghannon $1\frac{1}{4}$ miles south of Waringstown. The thunder ceased when the storm-cloud got overhead, and before the rain commenced a noise resembling a distant waterfall was heard. Immediately, precipitation began in a dense sheet obliterating objects 50 yards away. This was at 7.0 p.m. B.S.T. About seven minutes later hail began which pelted and rang off the gauge like small shot, and destroyed much rose bloom. At 8 o'clock the precipitation ceased as suddenly as it began. 0·27in. of rain had fallen during the ten minutes.

Heavy Rain

I was able to record particulars of a heavy shower this morning which seemed to be very unusual in intensity.

The rain lasted for less than five minutes; the amount measured was 0·10in. The screened thermometer fell 6°, from 69° to 63°F., and began to rise again immediately the rain ceased. Rain began at 9h. 37m. and ceased at 9h. 42m. G.M.T. approx. M. A. CARLISLE CROWE.

Pye Hill, Finchampstead, Berks. July 19th, 1931.

Severe Rainstorms in America

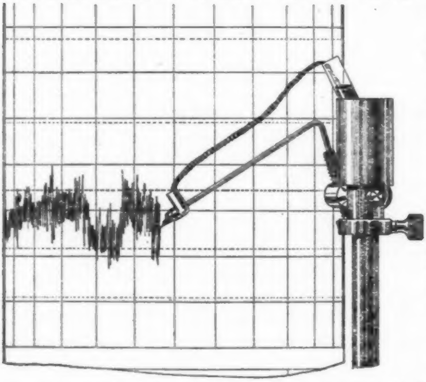
One of the heaviest and longest rainstorms for years was experienced in Maine and Massachusetts from June 7th-10th. Mr. Earl Austin of 52, James Street, Auburn, Maine, has sent the following details. The storm appeared as a slight depression centred over Kansas at 8h. (75th W. Meridian Time) on Friday, June 5th. At that time an anticyclone was centred over South Dakota, pressure was comparatively low over the north-eastern part of the United States and high to the south-east. By Saturday the depression had deepened and moved north-eastwards, causing showers and thunderstorms from Nebraska and Kansas to Ohio and Michigan; 1·46in. fell at Chicago, but in Maine the weather was clear and fine with northerly winds. On Sunday as the depression approached the weather in Maine became overcast and showery, and two thunderstorms accompanied by torrential rain occurred in the afternoon. From then until Wednesday heavy rain and thunderstorms continued at intervals. Usually the storms move away north-eastwards, but a high pressure area formed over Nova Scotia and Cape Breton Island, and there was also a wedge of high pressure from Ontario to Florida. "Thus the storm was wedged between both highs, and therefore rain continued to pour down." Boston had 4·22in. in the 24 hours ending at 8h. on the 10th. At Fitchburg, Mass., 6·12in. fell in the four days 7th-10th; at Lewiston 3·21in. or nearly a month's rainfall in four days. But for the numerous

power dams and storage lakes on the rivers concerned there would have been serious flooding. The flow over the dams was four to five times the normal. The Merrimac River at Lowell rose 5ft. in 24 hours; cellars were flooded and cattle marooned. On the 9th and 10th gales also were experienced along the coasts of Maine and Massachusetts. On Thursday, the 11th, the storm, still blocked by the high pressure area over Cape Breton Island, retreated towards Bermuda, which is very unusual.

New Ink-Feed for the Dines Pressure Tube Anemograph

Owing to failure on several occasions of the ink supply to the velocity pen of the Dines pressure tube anemograph, especially during periods of high winds at night time, an endeavour was made to maintain a continuous flow of ink in the following manner :—

A small and light glass tube 1¾in. long and ¼in. diameter (the one actually employed being of a type often used to contain flints) was placed at a slant in the shot cup on the float rod and shot removed to allow for the extra weight. The ink was



then fed from this reservoir to the pen by a single strand unravelled from the three-strand wick as used for the wet bulb; a complete wick maintains too copious a supply. This strand should be soaked in water before use. It is found that with the tube at a slant no support is necessary to keep the wick clear of the shot cup. The arrangement described has worked satisfactorily for a month in calm and boisterous weather, and the ink supply to the velocity pen has always been adequate without being excessive. The supply may be controlled in two ways: either by using thinner wick or by altering the amount of ink in the reservoir and thus a satisfactory flow may be found by experiment. Another important feature is to ensure that the end of the wick is within one millimetre of the penpoint. Once a correct flow has been obtained the velocity pen will work without attention for periods of a week or more.

F. E. Coles.

502, *Ulster Bomber Sqdn., R.A.F., Aldergrove, Co. Antrim.* *April 9th,* 1931.

NOTES AND QUERIES

New Meteorological Office at Wellington, New Zealand

By the courtesy of Dr. E. Kidson we are enabled to publish a photograph (see frontispiece of this number of the Magazine) of the new building of the Meteorological Office at Kelburn, Wellington, which was officially opened on October 28th, 1930. It is situated on an eminence overlooking the city, at an altitude of 400 feet. The upper room, which has windows on all sides, is the forecasting room and the upper roof is used for pilot balloon observations. A fireproof safe for the storing of records is provided in the basement.

Visibility Observations at Nuremberg

A note recently issued by the German Aviation Weather Service (Flugwetterdienst—April 6th, 1931) gives an account of a series of observations of visibility made at Nuremberg during the 4 months November, 1930, to February, 1931, inclusive.

The observations were made from a tower, in the middle of Nuremberg, which rises about 50 metres (160 feet) above the general level of the housetops. The observations were made both by day and by night, the observations at night depending upon observations of lights at different distances. The following tables shows the percentage frequency of visibility less than 1Km. (occurrence of fog) at the different hours of observation. The observations in bold type are those which depended upon observations of light, the other observations depending upon the ordinary daylight.

Time	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23 h
Nov. 30	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**0** 29	33	40	27	27	23	17	13	7	10	**10** 10	**7**	**7**	**7**	**3**	**0**	**3**%
Dec. 30	**6**	**13**	**19**	**16**	**16**	**16**	**16**	**19**	78	84	84	61	42	36	29	23	29	**26**	**26**	**19**	**16**	**3**	**6**	**6**%
Jan. 31	**8**	**8**	**3**	**3**	**3**	**0**	**8**	**10**	55	55	39	32	29	26	19	16	13	25 **27**	**19**	**16**	**10**	**3**	**3**	**3**%
Feb. 31	**4**	**11**	**7**	**11**	**11**	**11**	**14**	**28** 60	64	57	57	43	28	18	14	14	14	**6** 6	**11**	**7**	**4**	**7**	**4**	**4**%
Mean per cent.	**5**	**9**	**8**	**8**	**8**	**8**	**10**	**16** 45	58	59	52	41	31	24	19	15	14	14 **17**	**16**	**12**	**9**	**4**	**3**	**4**%

The great increase in the percentage of fog just after dawn finds no corresponding decrease in the percentage of fog after sunset, indicating that the effect is real and not due to the difference between observations of daylight visibility and observations of lights. It appears to be largely due to the smoke caused by Nuremberg itself, because the percentage frequency of fog at the aerodrome outside Nuremberg is much less in absolute value and does not show any great increase after dawn.

(The observations on the aerodrome were daylight observations only.)

A feature of more than usual interest in the note is a diagram based upon the observations of a searchlight situated on an aerodrome 9Km. west of the observation tower. The searchlight was turned on for 5 minutes every hour during the night. It was a very powerful searchlight (190,000 candlepower) and the light was directed towards the observation tower. On the average the light was visible in about 80 per cent. of the cases. The following diagrams show the percentage of occasions on which

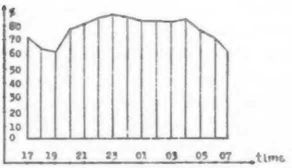


Fig 1. Percentage frequency of visibility of a searchlight.

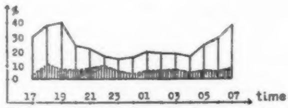


Fig. 2. Percentage frequency of invisibility of a searchlight.
Invisible owing to snow.
Invisible from all causes including snow.

it could be seen and the percentage of occasions on which it was not visible either through snow or through fog and haze. (While the number of occasions of snow are distributed practically uniformly throughout the period, there is a very definite maximum number of occasions of fog or haze in the evening after sunset and in the morning just before sunrise.)

E. GOLD.

High-Level Thunderstorms in Switzerland

During the afternoon and evening of June 23rd, I observed a series of thunderstorms from an Alpine hut at 11,000 feet, commanding a wide view over the mountains, and also over the foot-hills and plains to north-west. The base of the cumulo-nimbus clouds was at about 12,500 feet, both over the mountains and the plains. The storms over the lower ground were more numerous and pronounced, and had not crossed the Alps, but were moving quickly from south-west, roughly parallel to them. They were elongated from south-west to north-east. There were some lower clouds with a base at about 7,000 feet and some of these slowly grew up into the thunderstorms, but it was evident that the thunder clouds were not drawing on the lower layers to any considerable extent. There were a few flashes right down to the lower hills, but most of the flashes observed were complex and more or less horizontal, ranging up to perhaps ten miles in length, roughly 1,000 feet below the cumulo-nimbus base. Brush discharges caused much hissing, and were often pronounced under cirriform anvils of little opacity. On one occasion a

marked brief intensification of the discharges occurred immediately after a long flash some miles off. The noise of a brush discharge is quite different from the peculiar noise caused by a very near flash, just before the thunder, which resembles that of a red hot poker plunged into water, but is extremely brief.

A storm on July 6th moved rapidly from south-west, although the lower clouds up to 8,000 feet moved from north-east. This storm left the lower hills white with hail, and there was almost continuous thunder in the anvil.

It is of some interest to note that the cool out-rushing squalls associated with heavy precipitation in local thundersorms are not purely superficial, but extend up to 8,000 feet in storms arriving in the hills from lower ground.

C. K. M. DOUGLAS.

Whirlwind in Dungavel

The following is extracted from the climatological return made by Mr. P. E. Kirton, Observer, at Dungavel, Lanarkshire, for July :—

" A whirlwind of some violence occurred at the farm of High Dykes, situated approximately 1 mile north-east from this station. Time—5.10 p.m. on the 14th. Direction—Travelling east to west.

Considerable structural damage to farm buildings—one side of a roof being completely removed; currant and gooseberry bushes uprooted.

Owner of farm states that there was considerable noise of a hissing character. The occurrence was visible in the form of a pillar of white vapour, and he places the height at approximately 1,500 feet.

A track in the grass some 16 feet wide was visible over some 500 yards. Trees were drawn together as by suction. Slates were carried high in the air and remained poised aloft for a short period.

There was no appreciable wind at the time and no rain fell."

A. H. R. GOLDIE.

Snow in June

The climatological station at Roade reported slight snow on June 2nd, 1931; Mr. R. W. Janes, who is in charge of this station confirmed that a few snowflakes occurred, unaccompanied by rain. The minimum temperature measured at 9 a.m. G.M.T. on that day was 50°F., and at 9 a.m. next day 48°, temperature reaching 63° at some time between those hours. The synoptic weather chart for that day revealed an exceptionally well-marked nearly stationary front across northern England separating northerly winds from very high latitudes behind a Scandinavian depression and southerly winds in front of a depression far out on the Atlantic south-west of Ireland. Very

heavy rain fell on the night June 2nd-3rd in northern England, but there was no measurable precipitation at Roade. Observations of temperature in the upper air showed that at South Farnborough the freezing point occurred at about 8,000 feet in the morning and at fully 10,000 feet in the afternoon; at Duxford (near Cambridge) all observations gave the corresponding heights as a little over 8,000 feet. It would be of interest to know whether any reader of this magazine observed the occurrence of sleet or snow on that day. E. V. NEWNHAM.

Insplashing into and outsplashing from the funnel of a rain-gauge

With reference to the note published under the above title,* [and to Col. Gold's article on page 153] the following comments from Mr. C. E. Golding, Forest Gate, London, may be of some interest. For June 18th, 1930, Mr. Golding measured 2·24in. of rain. Of this about 1·61in. fell in 65 minutes, and after an interval of an hour about ·63in. in 38 minutes. He writes " when the mud splashes on the outside of the gauge had dried, the highest splash was about half an inch from the top edge of the gauge. No mud had dried inside, which looks as though there was no rebound into the gauge." The gauge is of the standard pattern with the rim eleven inches above the ground. The gauge stands on short grass " rather sparse." The rain in the gauge was noted to be clean. J. GLASSPOOLE.

Totland Bay Meteorology, 1930

It gives us much pleasure to receive each year copies of the annual meteorological reports compiled by the authorities in control of various municipal and private stations. Many of these reports contain valuable summaries of data for past years and thus constitute very substantial contributions to local climatology. One of the best is supplied by Mr. John Dover, M.A., of Totland Bay, Isle of Wight. The summary for 1930, a copy of which has recently been received, contains a number of interesting tables and diagrams, including a comparison between daily mean maximum and minimum temperatures at Totland Bay and Greenwich. The Totland figures are based on 44 years' observations, while Greenwich is represented by normals for both 65 and 90 years beginning in 1841. In regard to the maximum, Greenwich is markedly warmer than Totland in spring and summer, the greater warmth at Greenwich beginning early in February and ending late in October. The mean minimum, on the other hand, is always lower at Greenwich, the effect being smallest in June.

* *London, Meteorological Magazine* 64, 1929, pages 118-9.

Readers interested in the climate of the Isle of Wight would do well to consult this report, which is, we notice, the thirty-first of the series.

News in Brief

At a meeting of the Prussian Academy of Sciences on July 30th, Dr. G. C. Simpson, C.B., F.R.S., Director of the Meteorological Office, London, was elected a Corresponding Member of the Physical-Mathematical Section of the Academy.

The Rainfall Atlas of the British Isles was published by the Royal Meteorological Society at the price of 15s. 9d. (Fellows 10s. 9d.). The Council has now decided to issue a limited edition at the price of 7s. 6d., and arrangements have been made for Fellows to obtain copies at the special price of 5s. 6d.

The Weather of July, 1931

Pressure was below normal over Canada and the United States, Iceland, Spitsbergen, north-west, central and south-west Europe including the British Isles and France, south-west Asia and a small area from Algiers to Madeira, the greatest deficits being 4mb. in Utah, 8·1mb. at Thorshavn and 6mb. south-east of the Black Sea. Pressure was above normal over Mexico, in a wedge extending over the western North Atlantic to Newfoundland and Greenland, over the southern Iberian Peninsula and most of Russia, the greatest excesses being 3·9mb. at Lat. 40° N., Long. 40° W. and 4·9mb. at Ekaterinburg. Temperature was above normal over Spitsbergen and western Europe generally except in the extreme south-west. In Sweden it was 2°-3°F. above normal in Norrland, but elsewhere normal or a little below. The rainfall in Sweden was irregularly distributed, being deficient in eastern Svealand and about twice the normal in Scania and Vesterbotten.

Unsettled weather with a moderate temperature prevailed generally over the British Isles during July. Thunderstorms were frequent, accompanied in some cases by reavy rain and sunshine was markedly below normal. A depression persisted off north-west Scotland during the first few days of the month, and dull conditions with rain at times prevailed in the north and west, 2·07in. of rain fell at Hawkshead (Lancashire) on the 3rd, although amounts elsewhere were small. In the south-east the weather was mainly dry and often sunny. Lowestoft reported 15·3hrs. of sunshine on the 3rd, when maxima exceeded 75°F. locally on the east coast. Subsequently to the 5th this depression developed into a complex low pressure area which influenced the weather over the country generally until the 20th. During this time conditions were mainly unsettled and changeable. Thunder-

storms were experienced on the 5th-7th, 9th, 12th-15th and 19th. Rainfall amounts were usually small except during some of the thunderstorms and at the onset of fresh secondaries, 1·99in. fell at Oving House (Buckinghamshire) on the 7th, 1·78in. at Falmouth on the 11th, 2·07in. at Crossdoney (Co. Cavan) on the 13th, and 2·03in. at Nettlebed (Oxfordshire) on the 14th. Bright sunny periods were frequently experienced, especially earlier in the month; 14·5hrs. bright sunshine occurred at Ballinacurra (Co. Cork) on the 6th, 14·9hrs. at Deal on the 9th, 14·3hrs. at Dover on the 11th, 12·9hrs. at Rhyl on the 13th, and 12·3hrs. at Oban on the 15th. The 9th was a very warm day in east Scotland, 78°F. being reached at Leuchars and 76°F. at Dundee, but after severe thunderstorms the temperature fell considerably and maxima only rose to 51°F. and 52°F. locally on the 10th. Maxima were also below 60°F. at some places over the whole country on several other days in the month. High day temperatures occurred in south-east England on the 12th, when Greenwich reported 81°F. and Shoeburyness 80°F. On the 20th an anticyclone moved eastwards across the British Isles, and fine warm weather was experienced over most of the country on that day and the 21st. On the 23rd a depression approaching the north-west coasts caused the weather there to deteriorate, but it still remained fine and warm in the south and east; 80°F. was again reached at Greenwich on the 23rd and 24th; 14·3hrs. bright sunshine occurred at St. Ives on the 21st and 13·9hrs. at Hastings and Eastbourne on the 23rd. On the evening of the 24th the depression to the north-west moved across the country and rain, heavy at times, occurred over the whole country on the 25th, 1·59in. was recorded at Barnsley (Yorkshire). From then until the end of the month conditions were very unsettled, rain falling on most days except in parts of the south-east, but there were long bright intervals, 13·8hrs. bright sunshine occurred at St. Ives on the 27th. Rainfall was generally above normal for the month. For the fourth successive month sunshine was deficient over practically the whole country, the distribution during July being as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	104	— 41	Liverpool	150	—43
Aberdeen	83	— 76	Ross-on-Wye	131	—68
Dublin	93	— 77	Falmouth	163	—62
Birr Castle	100	— 44	Gorleston	179	—52
Valentia	145	— 14	Kew	151	—50

The special message from Brazil states that the rainfall in the northern and central regions was generally scarce, with an average 0·04in. and 0·43in. below normal and in the southern regions irregular with an average 0·20in. above normal. Pressure distribution was abnormal with 3 anticyclones passing across the country and depressions over the south and west. The crops were generally in good condition in spite of frosts.

At Rio de Janeiro pressure was 0·4mb. above normal and temperature 1·1°F. above normal.

Miscellaneous notes on weather abroad culled from various sources.

All the Swiss Alpine roads were open to vehicular traffic by the 2nd. After a long drought there were heavy rainstorms over Denmark on the 8th; the hay crops were spoiled and many bridges carried away. A severe gale occurred at Lublin (Poland) on the 21st (*The Times*, July 2nd-23rd).

It was announced on the 6th that the Nile was lower than it had been for 20 years (*The Times*, July 7th).

The monsoon was fully established at Bombay by the 3rd, and was extremely active during the month, Bombay having a heavier rainfall than normal. Good rains were reported in north Hyderabad, Malabar, Central India, and in the Central Provinces during the first part of the month, but elsewhere the rains were local. The floods in Kwangtung, which extended as far as Canton, were subsiding on the 7th. On the 26th the continuance of heavy rain in the Chinese coastal provinces and in the interior beyond Hankow were causing increasing anxiety especially for the rice crops, though farmers were endeavouring to drain their paddy fields; the railway lines had been breached in several places by the floods. Snow fell on Fujiyama on the 11th, an almost unprecedented occurrence in July. Heavy rains had fallen throughout Japan for more than a week previous to this, and also local storms (*The Times*, July 3rd-27th).

Four people were killed in a violent storm in Sydney on the 6th. The wind reached a speed of 70 m.p.h. and 5ins. of rain fell in 18hrs. Very cold weather accompanied by much snow occurred in the southern half of South Island, New Zealand, during the earlier part of the month. A severe gale was experienced in the Chatham Islands from the 17th-20th (*The Times*, July 7th and 21st).

High temperatures occurred over eastern Canada during the first few days, 96°F. being recorded at Montreal on the 1st. After this general rains fell over Canada and improved the crop prospects slightly, but later high temperatures caused further damage to crops in some sections of the prairies. Excellent conditions for the crops prevailed east of the Great Lakes. Temperature was above normal over most of the United States, being as much as 15°F. above normal at Sheridan and Reno, Mountain Regions, for the week ending the 28th. Rainfall was variable. (*The Times, July 2nd-21st, and Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

Rainfall, July, 1931—General Distribution

England and Wales	**153**	**per cent of the average 1881-1915.**
Scotland	**136**	
Ireland	**121**	
British Isles	**142**	

Rainfall: July, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Lond .	Camden Square	3·00	126	*Leics* .	Belvoir Castle	4·41	181
Sur .	Reigate, Alvington	2·99	133	*Rut* .	Ridlington	3·35	133
Kent .	Tenterden, Ashenden	2·29	109	*Linc* .	Boston, Skirbeck	5·18	235
,, .	Folkestone, Boro. San.	3·23	...	,, .	Cranwell Aerodrome	3·73	160
,, .	Margate, Cliftonville	3·92	198	,, .	Skegness, Marine Gdns	4·29	197
,, .	Sevenoaks, Speldhurst	3·00	...	,, .	Louth, Westgate	3·91	157
Sus .	Patching Farm	4·28	178	,, .	Brigg, Wrawby St.	4·49	...
,, .	Brighton, Old Steyne	3·01	138	*Notts* .	Worksop, Hodsock	3·88	171
,, .	Heathfield, Barklye	4·15	166	*Derby* .	Derby, L. M. & S. Rly.	3·49	147
Hants .	Ventnor, Roy. Nat. Hos.	2·87	142	,, .	Buxton, Devon Hos.	4·44	113
,, .	Fordingbridge, Oaklnds	3·33	166	*Ches* .	Runcorn, Weston Pt	2·53	92
,, .	Ovington Rectory	3·81	148	,, .	Nantwich, Dorfold Hall	4·27	...
,, .	Sherborne St. John	3·72	167	*Lancs* .	Manchester, Whit. Pk.	3·71	112
Berks .	Wellington College	4·44	214	,, .	Stonyhurst College	4·23	109
,, .	Newbury, Greenham	4·10	185	,, .	Southport, Hesketh Pk	2·69	94
Herts .	Welwyn Garden City	3·31	...	,, .	Lancaster, Strathspey	5·86	...
Bucks .	H. Wycombe, Flackwell	3·71	...	*Yorks* .	Wath-upon-Dearne	3·29	132
Oxf .	Oxford, Mag. College	3·09	136	,, .	Bradford, Lister Pk	3·28	119
Nor .	Pitsford, Sedgebrook	3·53	149	,, .	Oughtershaw Hall	6·57	...
,, .	Oundle	2·89	...	,, .	Wetherby, Ribston H.	4·13	165
Beds .	Woburn, Crawley Mill	3·74	168	,, .	Hull, Pearson Park	3·77	161
Cam .	Cambridge, Bot. Gdns.	3·30	153	,, .	Holme-on-Spalding	3·45	...
Essex .	Chelmsford, County Lab	3·17	149	,, .	West Witton, Ivy Ho.	3·12	119
,, .	Lexden Hill House	3·49	...	,, .	Felixkirk, Mt. St. John	3·80	139
Suff .	Hawkedon Rectory	3·15	129	,, .	Pickering, Hungate	4·19	156
,, .	Haughley House	3·10	...	,, .	Scarborough	3·33	137
Norf .	Norwich, Eaton	3·28	127	,, .	Middlesbrough	4·78	187
,, .	Wells, Holkham Hall	3·65	157	,, .	Baldersdale, Hury Res.	4·14	..
,, .	Little Dunham	3·91	142	*Durh* .	Ushaw College	3·48	125
Wilts .	Devizes, Highclere	4·55	196	*Nor* .	Newcastle, Town Moor	3·43	129
,, .	Bishops Cannings	4·61	185	,, .	Bellingham, Highgreen	5·08	154
Dor .	Evershot, Melbury Ho.	4·38	173	,, .	Lilburn Tower Gdns.	3·77	152
,, .	Creech Grange	4·31	176	*Cumb* .	Geltsdale	6·86	...
,, .	Shaftesbury, Abbey Ho.	3·93	153	,, .	Carlisle, Scaleby Hall	4·23	129
Devon .	Plymouth, The Hoe	4·82	175	,, .	Borrowdale, Seathwaite	15·90	188
,, .	Polapit Tamar	6·78	251	,, .	Borrowdale, Rosthwaite	11·12	...
,, .	Ashburton, Druid Ho.	...	..	,, .	Keswick, High Hill	7·20	...
,, .	Cullompton	4·30	160	*West* .	Appleby, Castle Bank	5·51	174
,, .	Sidmouth, Sidmount	4·26	170	*Glam* .	Cardiff, Ely P. Stn.	4·41	142
,, .	Filleigh, Castle Hill	5·81	...	,, .	Treherbert, Tynywaun	10·94	...
,, .	Barnstaple, N. Dev. Ath	5·39	199	*Carm* .	Carmarthen Friary	6·39	182
,, .	Dartm'r, Cranmere Pool	9·60	...	*Pemb* .	Haverfordwest, School	5·80	181
Corn .	Redruth, Trewirgie	6·82	223	*Card* .	Aberystwyth	4·12	...
,, .	Penzance, Morrab Gdn.	5·17	190	,, .	Cardigan, County Sch.	3·11	...
,, .	St. Austell, Trevarna	7·47	223	*Brec* .	Crickhowell, Talymaes	3·70	...
Soms .	Chewton Mendip	4·99	143	*Rad* .	Birm W. W. Tyrmynydd	5·01	122
,, .	Long Ashton	4·45	157	*Mont* .	Lake Vyrnwy	4·44	129
,, .	Street, Millfield	4·11	164	*Denb* .	Llangynhafal	1·54	66
Glos. .	Cirencester, Gwynfa	...	...	*Mer* .	Dolgelly, Bryntirion	5·71	134
Here .	Ross, Birchlea	4·48	197	*Carn* .	Llandudno	1·22	51
,, .	Ledbury, Underdown	3·77	167	,, .	Snowdon, L. Llydaw 9	16·75	...
Salop .	Church Stretton	3·81	155	*Ang* .	Holyhead, Salt Island	1·71	65
,, .	Shifnal, Hatton Grange	3·19	142	,, .	Lligwy	2·56	99
Worc .	Ombersley, Holt Lock	2·54	119	*Isle of Man*			
,, .	Blockley	4·29	...		Douglas, Boro' Cem.	2·89	94
War .	Birminghm, Edgbaston	3·21	138	*Guernsey*			
Leics .	Thornton Reservoir	3·65	147		St. PeterP't. GrangeRd.	3·28	162

Rainfall: July, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per cent of Av.
Wigt	Pt. William, Monreith	3·61	128	*Suth*	Loch More, Achfary	7·21	135
,,	New Luce School	3·65	107	*Caith*	Wick	2·93	111
Kirk	Carsphairn, Shiel	6·79	129	*Ork*	Pomona, Deerness	...	...
Dumf	Dumfries, Crichton, R.I	4·50	...	*Shet*	Lerwick	3·87	169
,,	Eskdalemuir Obs.	5·74	140	*Cork*	Caheragh Rectory	2·19	...
Roxb	Branxholm	3·71	123	,,	Dunmanway Rectory	3·53	91
Selk	Ettrick Manse	3·70	83	,,	Ballinacurra	2·22	79
Peeb	West Linton	4·22	...	,,	Glanmire, Lota Lo.	2·89	100
Berk	Marchmont House	4·63	152	*Kerry*	Valentia Obsy.	3·84	102
Hadd	North Berwick Res.	4·29	166	,,	Gearahameen	6·80	...
Midl	Edinburgh, Roy. Obs.	3·57	136	,,	Killarney Asylum	4·11	124
Lan	Auchtyfardle	4·44	...	,,	Darrynane Abbey	2·92	77
Ayr	Kilmarnock, Agric. C.	...	...	*Wat*	Waterford, Brook Lo.	3·23	100
,,	Girvan, Pinmore	3·46	95	*Tip*	Nenagh, Cas. Lough	4·55	145
Renf	Glasgow, Queen's Pk.	3·65	125	,,	Roscrea, Timoney Park	4·59	...
,,	Greenock, Prospect H.	4·40	112	,,	Cashel, Ballinamona	3·87	133
Bute	Rothesay, Ardencraig.	6·60	150	*Lim*	Foynes, Coolnanes	2·87	93
,,	Dougarie Lodge	3·83	..	,,	Castleconnel Rec.	4·44	...
Arg	Ardgour House	9·14	...	*Clare*	Inagh, Mount Callan	5·11	...
,,	Manse of Glenorchy	7·70	...	,,	Broadford, Hurdlest'n.	4·18	...
,,	Oban	4·11	106	*Wexf*	Gorey, Courtown Ho.	3·96	135
,,	Poltalloch	3·95	96	*Kilk*	Kilkenny Castle	5·33	189
,,	Inveraray Castle	5·97	120	*Wic*	Rathnew, Clonmannon	2·94	...
,,	Islay, Eallabus	4·47	131	*Carl*	Hacketstown Rectory	4·57	133
,,	Mull, Benmore	13·20	..	*Leix*	Blandsfort House	3·44	110
,,	Tiree	3·59	...	,,	Mountmellick	...	...
Kinr	Loch Leven Sluice	5·27	183	*Off'ly*	Birr Castle	3·92	133
Perth	Loch Dhu	...	...	*Kild'r*	Monasterevin	3·31	...
,,	Balquhidder, Stronvar	6·67	...	*Dubl*	Dublin, FitzWm. Sq.	3·62	141
,,	Crieff, Strathearn Hyd.	4·82	162	,,	Balbriggan, Ardgillan.	3·72	137
,,	Blair Castle Gardens	5·65	221	*Me'th*	Beauparc, St. Cloud	3·19	...
Angus	Kettins School	3·64	154	,,	Kells, Headfort	3·54	111
,,	Dundee, E. Necropolis	4·95	181	*W.M*	Moate, Coolatore	3·39	...
,,	Pearsie House	4·60	...	,,	Mullingar, Belvedere	4·39	138
,,	Montrose, Sunnyside	4·44	169	*Long*	Castle Forbes Gdns.	4·66	149
Aber	Braemar, Bank	4·10	159	*Gal*	Ballynahinch Castle	4·76	115
,,	Logie Coldstone Sch.	4·03	136	,,	Galway, Grammar Sch.	4·24	...
,,	Aberdeen, King's Coll.	2·93	104	*Mayo*	Mallaranny	5·70	...
,,	Fyvie Castle	3·24	100	,,	Westport House	3·18	103
Moray	Gordon Castle	4·06	127	,,	Delphi Lodge	7·32	110
,,	Grantown-on-Spey	5·53	180	*Sligo*	Markree Obsy.	4·44	128
Nairn	Nairn, Delnies	4·41	165	*Cav'n*	Belturbet, Cloverhill	3·01	96
Inv	Kingussie, The Birches	4·62	...	*Ferm*	Enniskillen, Portora	...	...
,,	Loch Quoich, Loan	8·75	...	*Arm*	Armagh Obsy	5·74	198
,,	Glenquoich	9·54	149	*Down*	Fofanny Reservoir	6·54	...
,,	Inverness, Culduhtel R.	4·91	...	,,	Seaforde	2·74	86
,,	Arisaig, Faire-na-Squir	5·28	...	,,	Donaghadee, C. Stn.	2·71	97
,,	Fort William	5·11	...	,,	Banbridge, Milltown	2·74	...
,,	Skye, Dunvegan	4·51	...	*Antr*	Belfast, Cavehill Rd.	3·45	...
R & C	Alness, Ardross Cas.	4·03	133	,,	Glenarm Castle	4·08	...
,,	Ullapool	3·11	98	,,	Ballymena, Harryville	4·19	122
,,	Torridon, Bendamph	...	...	*Lon*	Londonderry, Creggan	4·41	120
,,	Achnashellach	6·48	...	*Tyr*	Donaghmore	...	...
,,	Stornoway	2·07	..	,,	Omagh, Edenfel	5·54	163
Suth	Lairg	3·57	114	*D.n*	Malin Head	3·00	...
,,	Tongue	3·51	115	,,	Dunfanaghy	4·71	...
,,	Melvich	4·55	...	,,	Killybegs, Rockmount	4·51	104

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Climatological Table for the British Empire, February, 1931.

STATIONS	PRESSURE		TEMPERATURE								Rela-tive Humi-dity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	Diff. from Normal	Absolute Max.	Absolute Min.	Mean Values Max.	Mean Values Min.	Mean Values ½ max. and min.	Mean Values Diff. from Normal	Mean Wet Bulb				Am'nt	Diff. from Normal	Days	Hours per day	Per-cent-age of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.		%	0—10	in.	in.			
London, Kew Obsy.	1012·1	−3·9	54	28	45·0	34·2	39·6	−0·5	36·0		88	8·3	1·46	−0·08	17	2·1	22
Gibraltar	1020·5	+0·5	70	42	63·9	47·7	55·8	−0·1	47·4		77	3·5	0·18	−4·04	6	..	..
Malta	1009·6	−6·5	63	42	56·6	48·0	52·3	−3·0	47·7		73	7·0	4·70	+2·50	20	5·6	52
St. Helena	1011·9	−0·3	73	59	69·4	61·0	65·2	−0·7	62·4		92	8·7	1·46	..	8	..	..
Sierra Leone	1008·4	−2·4	92	70	89·4	72·7	81·1	−1·2	73·3		70	3·4	0·03	−0·27	1	..	..
Lagos, Nigeria	..	..	95	74	90·8	78·2	84·5	+2·3	78·9		83	9·3	1·47	−0·60	5	..	..
Kaduna, Nigeria	1014·7	+1·3	97	..	92·1	..	..	..	69·9		72	..	0·00	−0·04	0	..	..
Zomba, Nyasaland	1008·1	+0·2	84	65	80·3	66·6	73·5	+1·5	..		79	7·7	10·25	−0·40	15	..	..
Salisbury, Rhodesia	1008·2	+0·7	85	57	80·6	60·6	70·6	+1·8	63·6		67	4·8	5·17	−1·65	12	8·0	63
Cape Town	1014·1	+0·7	100	56	81·9	62·4	72·1	+1·8	62·6		71	3·0	1·28	+0·70	4	..	..
Johannesburg	1011·5	+1·1	86	51	77·8	56·6	67·2	+1·6	59·1		66	3·4	2·44	−2·78	14	8·5	65
Mauritius	1011·9	+0·9	88	66	84·0	73·2	78·6	−0·7	75·6		78	7·0	21·45	+13·05	24	7·4	58
Calcutta, Alipore Obsy.	1014·0	+0·7	91	52	83·1	63·0	73·1	+1·9	63·1		83	3·0	2·90	+1·91	5*	..	..
Bombay	1012·1	−0·6	87	65	83·7	68·5	76·1	+0·4	65·6		69	0·5	0·00	−0·03	0*	..	..
Madras	1013·0	+0·1	90	63	86·4	68·7	77·5	−0·2	72·2		83	2·9	0·00	−0·30	0*	..	..
Colombo, Ceylon	1011·3	+0·5	92	71	88·1	73·9	81·0	+0·6	75·9		74	4·2	3·48	+1·54	6	8·9	75
Singapore	1010·5	..	92	71	90·4	73·8	82·1	+2·4	..		..	..	5·91	−0·71	10	7·1	60
Hongkong	1016·9	−1·7	78	50	64·7	58·5	61·6	+2·5	58·8		85	9·9	0·55	−1·20	9	1·0	9
Sandakan	..	..	89	74	86·9	75·2	81·1	+0·9	77·3		83	..	4·19	−6·78	5	..	..
Sydney, N.S.W.	1015·5	+1·6	104	51	77·0	64·6	70·8	−0·5	65·7		67	5·5	1·48	−2·72	14	7·3	54
Melbourne	1015·6	+1·1	99	47	77·6	53·4	65·5	−2·1	58·3		56	5·4	1·20	−0·51	7	8·6	63
Adelaide	1016·6	+2·4	103	51	83·5	57·9	70·7	−3·3	57·3		36	4·2	0·30	−0·42	6	10·2	77
Perth, W. Australia	1016·1	+3·1	102	52	81·7	60·1	70·9	−3·2	61·3		54	3·8	0·04	−0·41	1	9·5	72
Coolgardie	1015·1	+2·6	105	50	87·9	60·5	74·2	−2·0	59·6		39	2·3	1·21	+0·36	2	..	..
Brisbane	1013·5	+1·0	90	59	82·1	67·1	74·6	−1·9	69·5		70	7·0	19·09	+12·91	13	8·0	61
Hobart, Tasmania	1011·7	−1·5	85	41	71·0	51·6	61·3	−1·0	56·4		50	5·2	2·10	+0·62	11	8·2	59
Wellington, N.Z.	1014·7	−1·1	73	42	63·2	50·8	57·0	−5·6	53·7		73	6·5	1·63	−1·51	7	7·9	58
Suva, Fiji	1005·2	−2·6	88	72	84·9	75·6	80·3	0·0	76·1		83	8·0	21·52	+10·80	21	4·8	38
Apia, Samoa	1005·4	−3·0	88	73	85·2	75·8	80·5	+1·5	77·7		83	8·2	19·71	+4·42	23	4·5	36
Kingston, Jamaica	1013·2	−2·1	91	62	86·2	69·5	77·9	+1·4	67·2		81	2·9	0·16	−0·44	3	9·6	83
Grenada, W.I.	1013·3	−0·2	90	71	87·3	73·2	80·3	+3·2	73·6		75	4·2	3·34	+0·56	19	..	..
Toronto	1018·2	+0·2	43	0	33·2	20·0	26·6	+5·5	22·5		75	6·2	1·13	−1·25	8	4·2	40
Winnipeg	1019·6	−2·2	40	−21	26·3	9·5	17·9	+17·8	..		..	5·0	0·18	−0·56	2	5·2	51
St. John, N.B.	1013·6	−0·3	43	−6	29·7	16·9	23·3	+3·4	17·5		69	7·0	3·61	−0·29	12	3·1	30
Victoria, B.C.	1016·8	+0·2	51	32	47·4	38·9	43·1	+2·6	40·9		90	7·5	3·22	−0·04	14	3·9	38

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